MEASURING FINANCIAL PERFORMANCE OF COTTON WAREHOUSES

A Thesis

by

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ABSTRACT

Cotton warehouses play an important role throughout the supply chain in that they are the link between producers and mills. Warehouses in the United States have struggled in recent years from lower cotton production and increased reliance on exports. The goal of this study was to perform a financial analysis of a representative Texas cotton warehouse to determine the possible benefits of using new warehousing methods.

Three warehousing methods were examined: 1. Large Inventory MILLNet, 2. Small Inventory MILLNet, and 3. 4-Bale Clamp Load of Bales. Financial data was gathered from multiple representative Texas warehouses.

Data was also utilized from a time and machine study that analyzed the amount of time to load a container of bales from a warehouse. Capital budgeting and Monte Carlo simulation were utilized to create a baseline budget to simulate a warehouse's finances. Net income was simulated for the baseline warehouse along with each of the possible new methods.

The results were determined from comparing net income of the baseline to each scenario. It was determined that each scenario contributed to small financial gains. MILLNET software was determined to have the best results. Overall, warehouses had slightly higher net income when one of the three warehousing methods was incorporated.

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Thank you to my committee chair, Dr. Robinson, for going above and beyond in guiding me through this process. His patience and flexibility allowed me to complete this thesis. Thank you to my committee members, Drs. Park and Welch, for agreeing to be on my committee and sticking with me through the process. Also, I would be remiss if I do not mention Dr. Brock Faulkner, who graciously agreed to be on my committee and helped with much of the engineering portion of this project.

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CHAPTER I

INTRODUCTION

Overview

Texas is the number one cotton producing state in the United States with just under half the crop being grown there. Cotton plays a key part in the overall Texas economy as the crop produced in 2015 had a value of 1.6 billion dollars, making it the highest valued crop in the state (USDA NASS 2015). Many communities across Texas rely heavily on the cotton industry to provide jobs and economic support. There are multiple layers to the cotton industry beyond just growing the crop. The domestic cotton supply chain includes production, ginning, warehousing, and yarn spinning, as well as oil mills that process cottonseed. In total, the cotton supply chain provides 39,300 jobs to people across Texas (Dudensing et al. 2016).

Cotton warehouses in Texas account for 800 of the jobs provided throughout the industry (Dudensing et al. 2016). There are currently 79 registered cotton warehouses located in Texas (FSA 2015). The warehouses are spread out across the state to support the different growing regions, as can be seen in Figure 1. There is also a cluster of warehouses in the Dallas region because of the convenient access to rail lines and the recent designation of DFW as an ICE futures delivery point for cotton.

Cotton is farmed in most regions of Texas with the western areas growing the largest proportion of the crop. Figure 2 depicts the dispersion of cotton acres around the state. On average over the last 10 years, Texas has produced 5,286 million bales of cotton annually (USDA NASS 2015). It is by far the largest producing state in the country. Most states have cut back on cotton production in the last few years, while Texas production has been more stable. This is beneficial for Texas warehouses since they have a more reliable bale volume to work with than in other states. With most domestic yarn mills located on the East Coast, Texas cotton is primarily exported overseas. This means Texas warehouses are more likely to be required to move cotton quickly when foreign mills buy cotton for prompt delivery.

The warehouses across Texas vary greatly by size. The average warehouse holds just under 80,000 bales. There are 33 warehouses with a capacity under 50,000 bales, while 18 can hold over 100,000 bales (FSA 2015). Due to the varying sizes and locations, this study will account for these differences and will look at warehouses on a small, medium, and large scale. This will help the results apply to all warehouses, no matter the size.

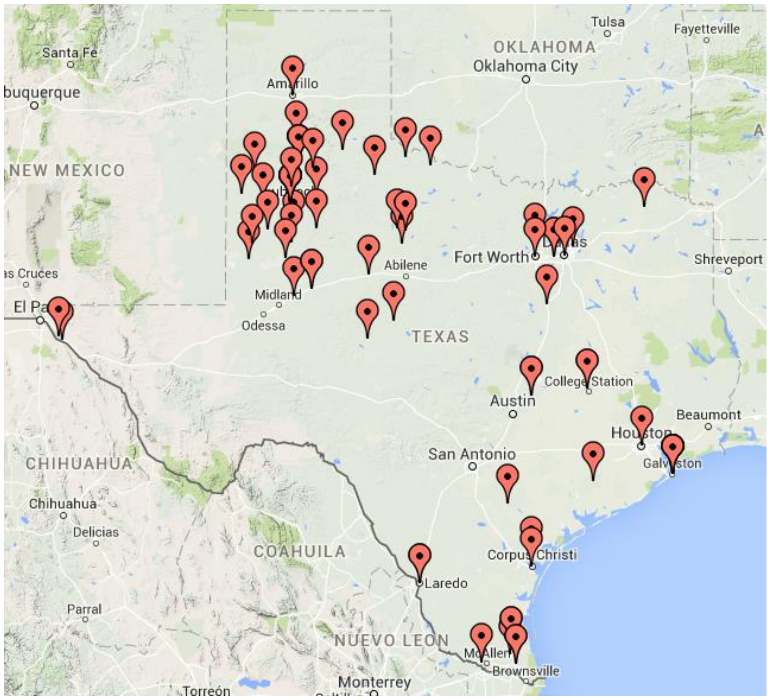


Figure 1 Map of Cotton Warehouse in Texas (USDA FSA 2015)

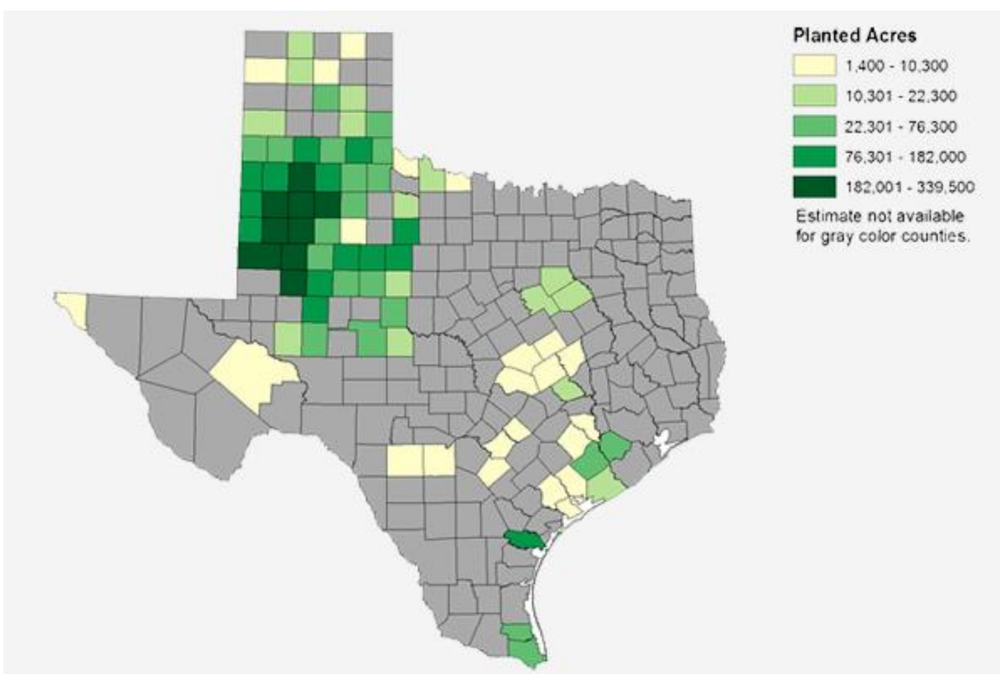


Figure 2 Map of Cotton Acres in Texas from the 2013 Crop (USDA NASS 2013)

The warehouses play an important role throughout the supply chain in that they are the link between producers and mills. Warehouses are used to store the cotton between the time it is ginned and when it is sold to a merchant and then shipped to a manufacturer. The importance of warehousing has grown in recent years as cotton has shifted away from being used domestically to the export market. The increase in exports has added a new complexity to the warehousing system. Merchants now need cotton moved from warehouses more quickly as the U.S. takes relatively longer to reach most destinations (Mexico would be the only exception). This has put a great deal of pressure on the logistics and transportation systems in the industry. The warehouses have had a somewhat difficult time keeping pace with shipments (Wilbur Smith Associates 2010). Before the mid-1990s, the domestic mills would buy cotton at a steady pace throughout the year, so each warehouse could gradually unload their inventory. Now there is great uncertainty when cotton will be moved, and the international buyers are heavily influenced by government actions and can come to the market at a moment's notice (Kenkel and Kim 2008). This has put a great strain on warehouses, as they must unload big portions of their inventory promptly.

In response to these changes, the cotton industry started the Vision 21 project in 2008 to help different segments of the industry overcome the new obstacles. One of the main focuses of the project was "logistical issues affecting U.S. raw cotton flow from the gin bale press through warehousing to the mill" (Wilbur Smith Associates 2010). The study was enacted to find a way for cotton to move through the warehouse at a lower cost while being able to meet the demands of the export market. The options considered for Vision 21 involved positioning of bales in a warehouse and ways to expedite the time it takes to assemble an 88-bale load (i.e., the amount required to fill a 40 foot shipping container). The first option explored is that of a 4-bale clamp load of bales (CLOB) that are sold together (Pace and Robinson 2010). This would hypothetically require fewer trips through the warehouse to acquire the necessary bales for a load, as those bales would already be stacked together. Warehouses would therefore be able to fulfill shipping orders faster.

Another option considered is greater adoption of software developed by Cotton Incorporated called MILLNet for Merchants. This software uses bale location data within a warehouse to help the merchant select bales to meet specific quality needs for their customers (Cotton Incorporated 1982). This would diminish the time needed to load and move bales, as the software would select the group of bales in the closest proximity. Hazelrigs (2016) looked at the potential time saving that could be found if either of these methods was adopted by an individual warehouse.

Both methods showed the potential to reduce the load time of bales, which would reduce the labor costs for a warehouse. However, it is not known if the cost savings are enticing enough to implement one of the strategies in the broader context of warehouse financial performance. This study will expound on the previous results and analyze whether either method is economically feasible in an aggregate firm context, while also considering risk.

Policy Context

In 1916, Congress passed the United States Warehouse Act (USWA), which enacted regulations throughout agriculture facilities to provide producers a safe place to store crops at a sensible price (USDA 2011). This act was updated in 2000, so it could better reflect the modern times. The updates were mainly brought about to improve the trade practices of the warehouses. This was done through establishing a warehouse receipt system, whereby there would be a standard documentation structure for commodities put into warehouses (USDA 2011). Warehouses have long been a part of the agricultural system in the United States and are still being updated to make the U.S. crops as competitive in the world market as possible.

There have been several measures already enacted by the cotton industry to help accelerate the flow of cotton through warehouses. According to the USDA (2014), a requirement for each warehouse approved by the Commodity Credit Corporation (CCC) is that they must make available 4.5% of their relevant storage capacity in a given week for shipment. It is not uncommon for warehouses to be delayed 60 days from getting cotton out of the facility, which causes issues for merchants who are trying to get cotton shipped quickly. This puts U.S. cotton at a disadvantage with overseas mills, as not only does it take time to get the cotton from the warehouse, but it also can take several weeks for the container vessel to get to the destination. Overseas mills are then inclined to buy cotton from a nearby country rather than wait for the U.S. cotton to arrive. The 4.5% rule has helped in making warehouses more accountable but doesn’t necessarily help cotton move through the warehouse more efficiently (Steadman 2014).

Industry Innovations

Warehouses have also tried to help the situation by establishing their own webpages for shipping orders to be made online rather than over the phone (Dizon 2010). This helps with the flow of data as merchants now have a place where they can easily check the status of a warehouse and coordinate accordingly to that information. For a warehouse, this is a somewhat inexpensive way to provide a tool for the merchant community that can give them real time information about the status of their cotton in any given warehouse.

Cotton as well as other farm program commodities can be put into the CCC loan program, which allows producers to get a government loan with their crop used as collateral. This would hypothetically restrict cotton flow though, as merchants are not allowed to move cotton that was in the loan program. Therefore, cotton cannot be transferred to warehouses with better port access and consequently remains stuck in the interior. This increases the required lead time when sales are made and merchants had to use cotton in the loan, as it had to be transferred to the port. This was changed in 2007 by the USDA. They will now allow cotton to be moved between registered warehouses while remaining in the loan program (USDA 2007). This helps merchants who can now position cotton near ports and eliminate that extra time once a sale is made.

Sources of Risk

Agricultural commodity warehouses face inherent financial risks from variable weather and government policies. These two factors are contributors to both the volume that is processed by a cotton warehouse and amount of time bales are kept in storage. The most difficult aspect of these risks is that a warehouse has little control of either.

The majority of cotton acreage in Texas is dryland and relatively more influenced by weather risk than irrigated cotton. This means there can be large swings in bales produced depending on the weather, especially rainfall, during the growing season. Figure 3 illustrates these swings, with 2009 to 2010 as a good example with a six million bales difference between the two years. Cotton is very dependent on timely rains throughout the growing season (i.e. drought can greatly impact yields). Severe droughts throughout much of Texas between 2011 and 2013 reduced the amount of cotton produced. This caused difficulties for cotton warehouses, as they had to sustain on less volume than they would normally handle on an average year.

Global trade can also have a large influence concerning how a warehouse is forced to operate. Figure 4 depicts just how reliant the U.S. cotton industry has become on the foreign markets. This shift to a primarily export market started around 1995 when the Multifiber Arrangement (MFA) started to be phased out. This agreement began in 1974 to establish import quotas with 40 countries, therefore boosting U.S. textile manufacturing, as imports were limited. When this began to be phased out in 1995, it boosted textile manufacturing across Asia, which caused the decline in U.S. manufacturing (Meyer, MacDonald and Foreman 2007). Warehouses then had to switch from mainly supplying domestic mills throughout the year to moving cotton through the warehouse quickly, so it could be shipped to foreign destinations.

Many areas of the United States cotton industry have had to make changes as the industry shifts to a primarily export driven market. The warehouses have had trouble adapting in this new environment. It is now becoming vital to make changes as profit margins are shrinking, and shipping delays are becoming part of the norm. Further research must be done in order to analyze if the solutions presented in the Vision 21 project can be viable to improve the financial landscape of the industry.

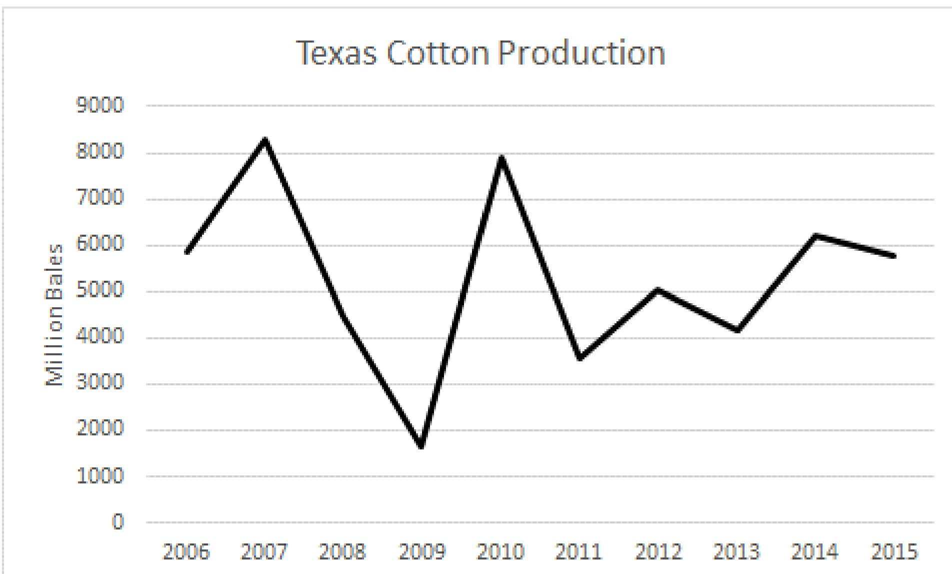


Figure 3 Historical Cotton Production in Texas (USDA NASS 2015)

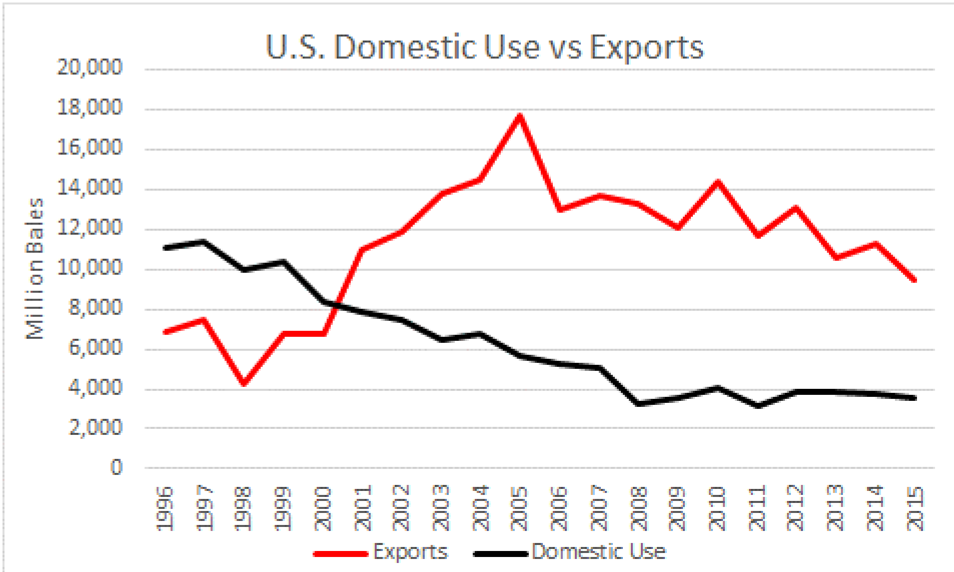


Figure 4 U. S. Domestic Cotton Consumption vs Exports (USDA FAS 2016)

Objective

The objective of this study was to analyze the financial impact of cost savings resulting from new warehousing methods in a representative Texas warehouse. The first step in the process was to create a budget simulation model of a warehouse to be utilized as the baseline. Data for the baseline numbers were collected from Texas warehouses in different regions of the State. With time savings having already been estimated by Hazelrigs (2016), the projected cost savings were calculated for a representative warehouse by taking the variable costs that were impacted (labor and equipment expenses) and calculating the cost per second. The projected savings was then calculated, incorporated with the firm's full financial statements, and evaluated for significance. This work would also not be complete if the supply and demand risks faced by a warehouse were not considered. The final step in this study was to simulate the finances of a warehouse, incorporating both the risks and possible savings to determine the risk efficient strategy for a Texas warehouse. The overall purpose of this study was to help warehouse managers decide if any of these techniques to improve the flow of cotton through their warehouse was financially feasible.

CHAPTER II

LITERATURE REVIEW

Few economic studies have focused on the cotton warehousing industry. Other reports (Vision 21) have documented the hardships and possible solutions, but have not evaluated methods nor reviewed the financial data to validate these suggestions. Vision 21 was an industry wide plan that was designed to address serious issues (flow, sustainability, and the Asian market). Each issue was studied and potential solutions were presented with further research needed to determine the actual benefits that could be achieved (Wilbur Smith Associates 2010). The present study will not only take a thorough look at the finances of a warehouse but will also account for the risks that a warehouse faces. This review will focus on the landscape of the Texas warehouse industry with a look at recent changes and provide a summary of the risks that the industry encounters.

Hazelrigs (2016) studied two methods that warehouses could possibly adopt to improve the speed of operations. This work looked at the 4-bale CLOB method and at using MILLNet for Merchants software from Cotton Incorporated. A baseline warehouse operation was created by gathering time and motion data from warehouses located in Texas and North Carolina. Data included bale location within a warehouse, the time required to move the bales, forklift speed, and distance traveled by the forklifts. The data were then analyzed to determine the time to load an 88-bale container. The Hazilrigs work determined that distance traveled by a forklift was the most significant factor in determining load time for a bale. Intuitively, this seems correct and reinforces the need for a system for selecting bales that requires the shortest drive time as possible.

The model created by Hazelrigs (2016) was used as a baseline for warehouse operations. The model was created from data from multiple locations and different warehouse methods (i.e. aisle stacking and block stacking), so that the model could be generalized and used by any warehouse. The size of the warehouse was evaluated, so that distance traveled could be properly assessed. Three different sized warehouses were modeled: small (5 sheds), medium (20 sheds), and large (40 sheds) with each shed having room for 50,000 bales. The baseline was the first model with bale selection being completely random for creating an 88-bale load. This finalized the baseline times for each warehouse size and operational method.

This thesis will primarily focus on aisle stacking due to the fact that the financial data is from Texas warehouses, which use the aisle stacking system. Block stacking is widely used outside of Texas and could benefit from further research regarding possible improvements; however, data limitations dictate that this thesis will represent aisle stacking warehouses. This methodology, though, could be easily adapted with proper data to a block-stacking warehouse.

Results from the Hazelrigs (2016) study showed that both 4-bale CLOB and MILLNet for Merchants could potentially lessen the time spent assembling loads when comparing the simulated results to the baseline. Baseline results showed that it takes the following times to pull together an 88-bale load. In a small warehouse, it took 40.1 minutes with a standard deviation of two minutes. A medium sized warehouse required

71.8 minutes to collect the bales with a standard deviation of 1.7 minutes. Finally, a large warehouse needed 124 minutes to assemble a load and had a standard deviation of one minute (Hazelrigs 2016). The 4-bale CLOB method was estimated to save two and one percent of the total time in small and medium sized warehouses, respectively. No time difference was found for large warehouses. MILLNet for Merchants showed more promising results than the four-bale CLOB. Timesaving of 2% to 17% were estimated when using MILLNet. The greatest savings were found in large warehouses and with merchants that owned greater than 60% of the inventory (Hazelrigs 2016). These results seem reasonable, since there should be greater time saving when a merchant owns a larger share of the existing inventory, as there are more bales to gather from in order to meet the quality specifications.

The Hazelrigs study was important since it discovered the time it takes an average warehouse to move bales. This article will expand on that effort and add the financial aspect to the already studied operations. Knowing the possible time saving was imperative for determining if any changes are financially feasible. This present research will complement and expand on Hazelrigs (2016) work, which will allow a warehouse to evaluate potential changes from both a time and financial viewpoint.

This present research adds to the scant number of economic studies of cotton warehousing. Kenkel and Kim (2008) investigated what was needed to be done to improve the shipping standard for cotton warehouses. Their results presented several possible solutions. The first solution concerned greater organization around selecting bales from a warehouse. This is being touched on in this study with possible use of the four-bale CLOB and MILLNet for Merchants. A second resolution was for more incentives to be provided for warehouses to improve infrastructure and thus be able to move cotton faster. It was noted, though, that this might have difficulty succeeding as merchants have stated that they are simply moving cotton according to customers' desires and therefore won't be paying additional premiums. A final point by Kenkel and Kim (2008) suggested that warehouses would benefit from knowing the classing information when the bale enters the warehouse, so that cotton could be sorted by quality entering the warehouse. The ending conclusion was that more research must be done to find the best solution. It was suggested that the next step was to quantify the costs of a warehouse so that potential options could be analyzed (Kenkel and Kim 2008). This study will take that first step of calculating the costs and also evaluate possible improvements to the bale selection process.

Roots, Hogan, and Robinson (2014) created a warehouse template that could be tailored to fit an individual warehouse by inputting tariff schedule, equity, and debt info. Plus, users could forecast their own expected bale volumes as a way to examine their warehouse under different scenarios. With cotton warehouses, the biggest uncertainties are around the bale volume that will be received and the average amount of time cotton will stay in the warehouse before being shipped out. The present study adds an extra step to this past research with the use of stochastic simulation to account for the uncertainty in bale volume.

This present research employs standard financial performance measures. Net present value has historically been a common method for examining capital budgeting problems. Barry, Hopkin, and Baker (1983) described NPV as one of the four common methods for analyzing capital budgets. NPV will be used in this analysis for analyzing the different scenarios, as it discounts cash flows back to present terms for comparison. Net cash income will also be used for comparing the different scenarios. This method has been used in other studies such as Richardson and Johnson (2013). Net cash income is able to quickly capture the impact that changes bring to the financial side of the business.

Stochastic simulation was originally suggested by Richardson and Mapp (1976) as a way to analyze problems under risk and uncertainty. This method allowed decision makers to view the range of possible outcomes. Stochastic simulation has long been used in agricultural economics with primarily farm and ranch operations assessed. Many of these studies have looked at production risks (Wailes and Chavez 2011; Flanders, Smith and McKissick 2006). Other works have examined the demand side and the risks associated (Schlecht, Wilson, and Dahl 2004). This study analyzes receiving (supply) and load-out (demand) risk for a warehouse. The empirical distribution will be used to simulate the stochastic variables (i.e. bales received and pace of shipments). This distribution was chosen, as it tends to be the best method when observational data are limited to less than 10 data points. With that few data points, there are not enough observations to use a traditional probability distribution (Richardson, Klose, and Gray 2000).

CHAPTER III

METHODOLOGY

Anderson (1976) wrote that simulation modeling is absolutely essential, as most good decisions are made knowing the likelihood of different outcomes occurring. This study employed capital budgeting and Monte Carlo stochastic simulation to model the operations of a cotton warehouse. Stochastic simulation enables risk to be accounted for when a business is analyzing choices to be made. This method provided the probability distribution around a given value, therefore showing the odds of an event occurring.

Financial modeling can also be done deterministically. Deterministic modeling does not include risk and gives just one outcome (e.g., net returns, or net present value) from the initial inputs. It can be used to give the minimum and maximum result along with the average. The downside to deterministic modeling is that it only gives one answer and does not account for the uncertainties that are likely to exist within businesses.

Stochastic simulation takes account of the risks involved around the key variables that have the greatest level of uncertainties. Bale volume was selected as the most variable input especially in dryland areas where yields can vary from year to year. The model for this study simulated these variables with all possible outcomes. There were 500 iterations simulated of a key output variable (i.e. net income), which will provide a probabilistic range of potential results. From the simulations, either a probability distribution function (PDF) or cumulative distribution function (CDF) was created to show the results of the key output variables (KOV) and help the business make a calculated decision. Stochastic dominance with respect to a function was also used as a way to rank the three alternative methods evaluated.

The steps in creating a stochastic simulation model are described by Richardson and Mapp (1976). The first step is to identify the variables that are most likely to influence the results of the business and create probability distribution for the variables thereby making them stochastic. Then the stochastic variables are merged into a deterministic model. Inserting the stochastic variables into a deterministic model allows for the KOVs to be simulated and the impact of the stochastic variables showcased.

The model for this study simulated the finances of two medium sized Texas warehouse under normal working conditions as a baseline. The warehouse operations can be altered to incorporate different sized warehouses and alternative bale moving techniques. The results of both simulations can be compared, and the best warehouse method can be determined from the results.

Stochastic Variables

The two primary stochastic variables used in this thesis were the number of bales received by the warehouse and the annual number of bales shipped out of the warehouse. These two variables capture the majority of the risk faced by a warehouse. Bale volume is the biggest determinant of warehouse performance, as the main focus of the warehouse is receiving and shipping bales. The amount of bales shipped from the warehouse can also be quite variable and has a direct relationship with how much revenue is generated, so it was included as a stochastic variable. These variables capture the revenue risks that a warehouses faces.

Key Output Variables

The conclusion from this study was based on two primary KOVs, which are net cash income and net present value. These will be the determinants that help conclude whether changes to warehouse operations can be valuable enough to implement. Stochastic simulation enables these variables to be simulated, and then PDF and CDF charts are used to examine the results as compared to a baseline.

Net cash income in this study was defined as revenue minus cash costs and interest expenses. This variable allows for the sensitivity of operation changes to be measured in terms of profitability for the warehouse. It was selected for this reason, as profitability is typically the main factor when businesses are considering changes. If modifications have good odds to improve cost-effectiveness, then businesses are likely to make the change.

Net present value (NPV) compares the amount originally invested to the future returns of the business. Returns are discounted based on the projected future inflation and the return desired by stakeholders. A positive NPV indicates that the business offers a rate of return greater than the discount rate, and the business is then deemed an economic success (Richardson and Mapp 1976). In this study, the simulated model output recorded a one for positive iterations and zero for negative runs. The probability of being an economic success will then be calculated by summing the NPV counter. The discount rate, r, is eight percent for this study. Barry, Hopkin, and Baker (1983) describe the mathematical calculation for NPV as:

$$NPV = -BeginningEquity + \sum_{t=1}^{5}\left(\frac{Dividends_t + \Delta AnnualNetWorth_t}{(1+r)^t}\right)$$

Ranking Risky Scenarios

Scenario analysis is useful as it gives decision makers many alternatives, so that they can select the outcome that they feel best profits their business. It is especially beneficial when risk and uncertainty are in play. Hardaker, et al. (2004) defines risk as uncertain consequences and uncertainty as imperfect knowledge. Warehouses face their biggest risks and uncertainties with the number of bales that will be received during a given growing season. Richardson (2008) describes risk as the one part of a business that the manager cannot control. This further illustrates the importance of applying simulation and scenario analysis to a business, so that the manager can make the best decision.

The difficulty though is ranking each scenario based on the decision maker's level of risk tolerance. Given this difficulty, tools have been developed to help with ranking scenarios. This study utilized stochastic efficiency with respect to a function (SERF) for analyzing NPV on both the baseline warehouses and three alternative scenarios.

SERF was introduced by Hardaker et al. (2004) as an improvement on the stochastic dominance with the respect to a function (SDRF) method using certainty equivalents (CE) for a range of risk levels. CEs are the guaranteed amount of money that a person would view as equal to a risky outcome, which puts the mean of the risky outcomes equal to the guaranteed money. In other words, it is the point on a utility function where the same level of value is expected no matter the outcome. The biggest drawback to this method is that utility functions must be calculated for each level of risk aversion.

SDRF was proposed by Meyer (1977) as a ranking method for risky scenarios by imputing the lower and upper bounds of risk aversion. This method can be useful when the chosen risk levels cross paths indicating a clear preference for a particular scenario. A limitation of SDRF is that if risk aversion levels are set too far apart, the results will not be consistent across the various risk levels. This is a particular issue given that it can be beneficial to set risk levels far apart so that a bigger group of decision makers are included (Richardson 2008).

SERF is able to rank each alternative simultaneously with all options considered and not just pair wise comparisons like SDRF. This is a major advantage as it creates a more efficient set over the same range of risk levels (Hardaker et al. 2004). SERF can also rank scenarios at all levels between the upper and lower risk aversion coefficients (RAC), rather than just at the upper and lower bounds (Richardson 2008). This study utilized risk levels from 0 to 4 divided by Net Worth. This methodology covers all the risk averse levels that a decision maker could fall into (Richardson 2008). A SERF analysis was run for each warehouse location with each scenario considered.

Validation

Simulated variables must be validated to ensure that they are representative of the historical data. Validation also includes verifying that all cell calculations throughout the model are correctly programmed. The simulated means of the stochastic variables are checked versus their historical means to ensure that they are equal. In addition, the variance of simulated variables must be checked against the historical variances. A Student's t test and F test can be used to check the simulated means and variances, respectively (Richardson 2008). If both tests fail to reject that they are equal, then the variables were accurately simulated.

Data Development

Data for this project were obtained from a variety of sources. The data relating to warehouse operations were obtained from multiple warehouses in Texas (Fields 2015; Harkey 2015). This information included the operating costs for warehouses along with revenues generated. The annual bales received and shipped were included as well. Warehouse data were used to estimate the average time that a bale remained in storage at the warehouse. As mentioned prior, the average time in storage can create large variances in revenue with warehouses earning income each month that a bale stays in storage. Warehouse tariff schedules were collected from the appropriate websites of the warehouses being studied. This information was used for determining the correct revenues that are generated for warehousing service.

Time data for warehouses were used from the study done by Hazelrigs (2016). These data were collected through a time and motion study at multiple Texas warehouses. The study determined the average time that it takes a bale to move completely through a warehouse system. This information was then modeled to incorporate possible warehouse changes to operations. This article utilized this time data to determine the possible cost savings than can be garnered from altering warehouse operations.

Financial Statements

Corporate financial statements were created for the different scenarios evaluated for a cotton warehouse. Adjustments were made to the assumptions for each bale moving scenario that was assessed.

Income Statement

Total annual revenue was calculated by summing each of the four warehouse services offered (i.e. receiving, storage and insurance, delivery, and miscellaneous services). Receiving revenue was calculated by multiplying the stochastic number of bales received by three dollars, which is the normal cost of receiving at warehouses across Texas. Storage costs are normally charged on a per monthly basis, so the amount of time spent in the warehouse must be determined for those revenues to be calculated. To estimate the storage revenue per bale, a ratio was created by dividing carry in bales by bales received. This shows on a proportionate scale how much of the current inventory has been accruing storage fees for more than just a couple of months. It was then determined from historical warehouse data that there was a strong positive relationship between this ratio and average storage revenue per bale. A simple regression was then utilized to generate storage revenue for each of the simulated years by taking the carry in ratio and estimating the revenue per bale from the regression. Regression statistics can be seen in Table 1. The regression produced an R^2 of 0.89, which indicates that 89% of the variation in storage revenue was explained by the carry in ratio. Each percent that the carry in ratio increases causes a 10 cent increase in the per bale revenue on top of the base of 8.79. Delivery revenue was calculated by using the standard tariff charged for bales to be taken out of the warehouse and then multiplied by the bales shipped during the fiscal year. Other revenues generated by a warehouse come from optional services offered such as expedited shipping and restocking bales previously marked for shipment. This study found that the average revenue generated per bale for other services tends to be static across past years. A historical value for other revenues per bale was multiplied by the number of bales received to determine revenue generated.

Table 1 Regression Statistics for Storage Revenue

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.94
R Square	0.89
Adjusted R Square	0.87
Standard Error	2.15
Observations	8.00

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1.00	230.37	230.37	49.73	0.00
Residual	6.00	27.79	4.63		
Total	7.00	258.16			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	8.79	0.98	9.01	0.00	6.40	11.17	6.40	11.17
Carry/Rcvd	10.55	1.50	7.05	0.00	6.89	14.21	6.89	14.21

Total expenses were created by summing all fixed and variables costs. Interest payments were also included in the costs for the income statement. No expense variables were modeled as stochastic. The expenses were split between variable and fixed, with the variable being calculated based on the number of bales received. The variable costs were a function of the number of bales received, but the cost per bale stayed steady across the simulated years. The interest expenses were from a property loan and from cash flow deficit loan interest. The property loan was calculated using a fixed payment amortization. The cash flow deficit was only paid in years when there were not enough funds to cover expenses. The total was calculated as the shortfall times the interest rate.

Net cash income was calculated by taking total revenue and subtracting total expenses. This is a good indicator of business performance as it takes into account most aspects of the operation each year.

Cash Flows Statement

Beginning cash in year one was set at $300,000 with the assumption that the warehouse being evaluated was financially healthy coming into the first year. In subsequent years, the beginning cash equaled the positive cash from the previous year's balance sheet. The summation of the beginning cash balance and net cash income gives total cash inflows.

Cash Outflows were calculated by summing loan payments, dividends, corporate taxes, and any repayments of short term operating loans. A corporate business structure was used to calculate federal income taxes. Taxable income is equal to net cash income minus depreciation. Dividends were paid out on 35% of positive net income as this is the standard payout for agribusiness cooperatives (Smith, Harmelink, and Hasselback 1998). The warehouse must borrow funds if ending cash is below zero. The loan covers the deficit to get ending cash to zero. This loan was considered a short term operating loan to be paid back in full the following year. Total inflows minus total outflows equals the ending cash balance for the business.

Balance Sheet

The balance sheet contains the value of assets, liabilities, and equity. Assets consisted of ending cash balances, land, equipment, building values, and miscellaneous items. Individual warehouses obviously should have their own items to add here. This model covers the larger items (land and buildings) while the other values should be minor in comparison. Liabilities were made up of the remaining balance of the long term loan on a yearly basis. Equity was the difference between assets and liabilities. Equity can also calculated as the summation of dividends, retained earnings, and book credits.

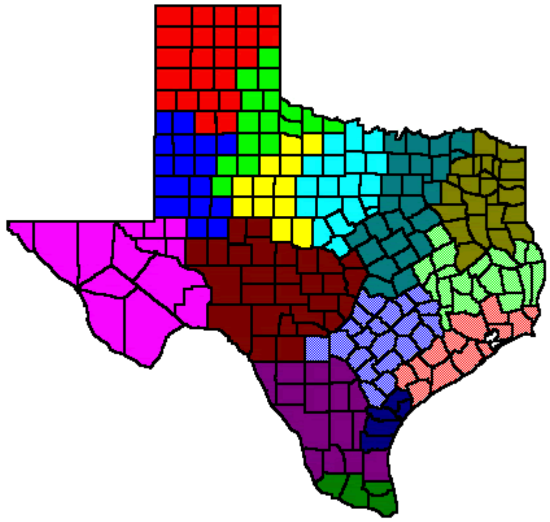
Assumptions

The assumptions used in the model to simulate warehouse results will be discussed in this section. As mentioned prior, the number of bales received and the average time spent in storage were the two variables modeled stochastically. Both fixed and variable expenses were left deterministic given low variability in changes over time.

The business was assumed to have a $15 million dollar capital loan that was used to expand warehouse space. Given that the warehouses being modeled had been in business for many years, the loan was assumed to have been first taken out in 2000. The interest rate on the loan is 7%. Operating loans for years with deficit cash flows were refinanced at 8% for one year. The operating loans were paid back the following year plus any interest charges.

The value of land was expected to appreciate 1% per year in this study (Fields 2015; Harkey 2015). Other assets are depreciated on a 30 year straight line basis. These assets were primarily buildings and equipment. Costs and tariff rates are adjusted based on long term forecasts of the consumer price index (CPI) and producer price index (PPI), respectively, by FAPRI (2016).

Ten years of annual regional cotton production data were collected for the areas that correspond to the warehouses involved (USDA NASS, 2015). NASS data provides a more accurate view on production than just simply using warehouse data on bales received. It allows all production risks to be incorporated into the simulation. Regional production data also enables this model to be easily adapted for other areas by simply using data from other districts or even states. Two areas of Texas were modeled: the Gulf Coast (NASS Districts 8-North, 8-South, 9, 10-North, and 10-South) and NASS District 1-South. Figure 5 depicts the Texas crop reporting districts on a map. These were selected because they are the most prominent dryland regions in the state and create large variations in volume for a warehouse. Figure 6 shows the historical data that was used as the baseline for forecasting the number of bales for the five years of simulation. The Multivariate Empirical distribution (MVE) was used to insure that the forecasted values matched their historical variation. These numbers were programmed into the model to determine revenues and variable costs.



Color Key	Code	Numeric Name	Geographic Name
	11	District 1-North	Northern High Plains
	12	District 1-South	Southern High Plains
	21	District 2-North	Northern Low Plains
	22	District 2-South	Southern Low Plains
	30	District 3	Cross Timbers
	40	District 4	Blacklands
	51	District 5-North	North East Texas
	52	District 5-South	South East Texas
	60	District 6	Trans-Pecos
	70	District 7	Edwards Plateau
	81	District 8-North	South Central
	82	District 8-South	Coastal Bend
	90	District 9	Upper Coast
	96	District 10-North	South Texas
	97	District 10-South	Lower Valley

Figure 5 Map of Texas Crop Reporting Districts (USDA NASS 2016)

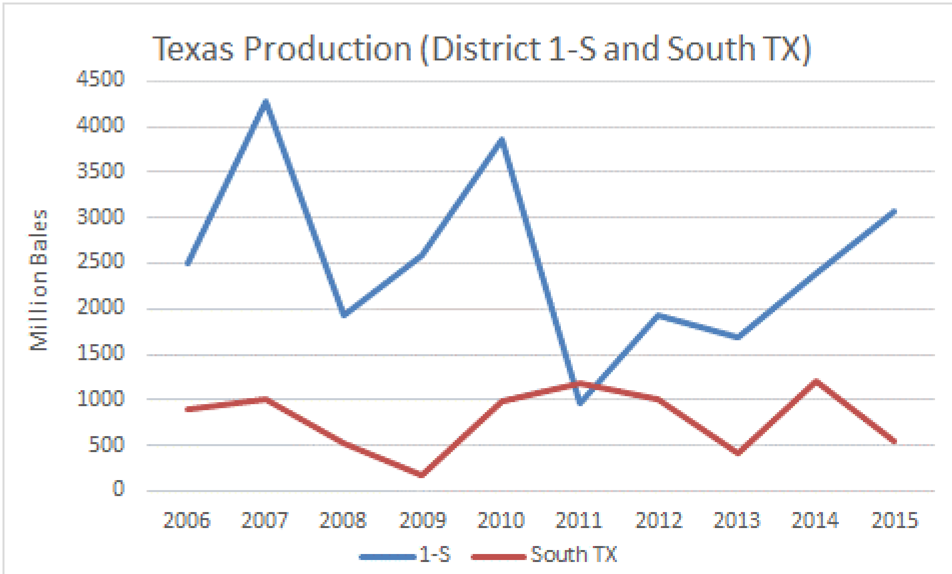


Figure 6 Historical Texas Production for District 1-S and South Texas (USDA NASS 2015)

Tables 2 and 3 display the average balance sheet for each warehouse over the five year simulation. The received and shipped figures were simulated, while the carry in and carry out were functions of the received and shipped figures. The number of bales received was trending lower in both warehouse locations. This was due to the reduction in production that has been seen in both regions over the last ten years. The primary reasons for this are fewer planted acres and dry weather, which limited the amount of cotton produced. While the number of bales received was declining, the carry out was increasing given a downward trend in the percent of bales shipped. As mentioned before, there is greater uncertainty of when cotton will be purchased with international buyers. So, the trend is upwards on carry out given the nature of the buying patterns in recent years. While the decline in bales received is concerning to a warehouse, the increase in carry out is beneficial for storage revenues.

Table 2 Average Bale Numbers Used for the South Texas Warehouse

	2016	2017	2018	2019	2020
Carry In	50	94	107	113	118
Received	453	445	437	429	421
Shipped	408	432	430	424	416
Carry Out	94	107	113	118	123

Table 3 Average Bale Numbers Used for the District 1-South Warehouse

	2016	2017	2018	2019	2020
Carry In	50	88	97	101	104
Received	416	403	390	376	363
Shipped	378	393	385	373	361
Carry Out	88	97	101	104	107

The warehouses being modeled were designed as medium sized warehouses located in two separate Texas regions. All costs were determined based on audited financial statements. The cost figures were left deterministic as they were a function of bales received rather than an outside force. Table 4 shows the average warehouse expenses used in the model.

Table 4 Average Warehouse Costs Used in This Analysis

Variable Costs	2016	2017	2018	2019	2020
Freight Rebate	2.52	2.54	2.58	2.62	2.65
Payroll Tax/Ins	0.56	0.56	0.57	0.58	0.59
Emp Ret/Ins	1.16	1.17	1.19	1.21	1.22
Materials/Supplies	0.11	0.11	0.11	0.12	0.12
Tags and Receipts	0.17	0.17	0.18	0.18	0.18
Repair Trk/Trctr	0.25	0.26	0.26	0.26	0.27
Repair Comp Mach&Equip	0.04	0.04	0.05	0.05	0.05
Fuel & Oil Trk/Trctr	0.12	0.13	0.13	0.13	0.13
Rep-Water System	0.06	0.06	0.06	0.06	0.06
Rep-Buildings	0.08	0.08	0.08	0.08	0.08
Rep-Yards/Roads	0.03	0.03	0.03	0.03	0.03
Equipment Lease	0.96	0.97	0.98	1.00	1.01
Utilities	0.40	0.40	0.41	0.42	0.42
Cotton Ins	0.22	0.23	0.23	0.23	0.24
Ins-Fire& Casualty	0.95	0.96	0.98	0.99	1.00
Claims	0.04	0.04	0.04	0.05	0.05
Trk/Trctr/Trlr License	0.01	0.01	0.01	0.01	0.01
Warehouse Rent	1.46	1.47	1.50	1.52	1.54
Temp Salaries	0.83	0.83	0.83	0.83	0.83
Gin Rebate	7.31	7.37	7.48	7.60	7.70
Fixed Costs	**2016**	**2017**	**2018**	**2019**	**2020**
Salaries/Labor	1,513,050	1,525,760	1,547,731	1,572,959	1,592,621
Telephone	38,303	38,625	39,181	39,820	40,318
Office Supplies	5,319	5,364	5,441	5,529	5,599
Dues & Subs	35,864	36,166	36,686	37,284	37,750
Advert/Promo	32,615	32,889	33,363	33,907	34,331
Computer Programming	15,255	15,383	15,604	15,859	16,057
Computer Supplies	3,787	3,818	3,873	3,937	3,986
Directors	22,544	22,734	23,061	23,437	23,730
Meetings	9,154	9,231	9,364	9,516	9,635
Travel & Meals	26,891	27,117	27,507	27,956	28,305
Electronic Receipts	4,939	4,980	5,052	5,134	5,198
Janitorial	4,081	4,115	4,175	4,243	4,296
Auto Expense	53,357	53,805	54,580	55,470	56,163
Bank Charges	11,109	11,202	11,363	11,549	11,693
Legal/Acctg	28,310	28,548	28,959	29,431	29,799
Repairs-Office Equip	3,430	3,458	3,508	3,565	3,610
Ad Valorem	206,784	208,520	211,523	214,971	217,658
Alarm Expense	20,174	20,343	20,636	20,973	21,235
Misc	5,044	5,086	5,159	5,243	5,309

Simulation Software

This study employed the use of Simetar© a Microsoft Excel add-in for the use of simulation. This software was developed by Richardson, Schumann, and Feldman (2008) as a tool for analyzing data and simulating risk. Models can be created in Excel and then easily changed depending on warehouse size and operation style. Finally, stochastic variables can be used to simulate the model under conditions of risk and uncertainty.

CHAPTER IV

RESULTS

The results shown in this chapter were based on the warehouses studied from two separate Texas regions. The outcomes of the simulation model will be analyzed in the form of two KOVs: NPV and net cash income. The results from the SERF analysis will also be shown as well as the findings from the stochastic variables (bales received and shipping pace). Each scenario is compared to the baseline, and a conclusion will be drawn as to the effectiveness of the method evaluated.

Stochastic Variables

There were two stochastic variables simulated in this study. They included annual bales received and annual bales shipped from the warehouse. An empirical distribution was used for the simulations of both variables. NASS cotton production data were utilized to simulate the number of bales received for each warehouse location. Shipping was based on actual warehouse data.

South Texas Warehouse

The number of bales received was replicated for each of the five simulated years (2016-2020). The average number of simulated bales for the South Texas warehouse was 437,000 with a coefficient of variation (CV) of 36.35%. Figure 6 shows the cumulative density function (CDF) of simulated bales received that was used in the simulation model for determining revenues and expenses. CDF’s are a standard statistical representations of the range of likely outcomes along with the associated probability of being at least as high as the amount shown in the graph. For example in Figure 6, there is a 30% probability that the number of bales received will be 400 thousand or less.

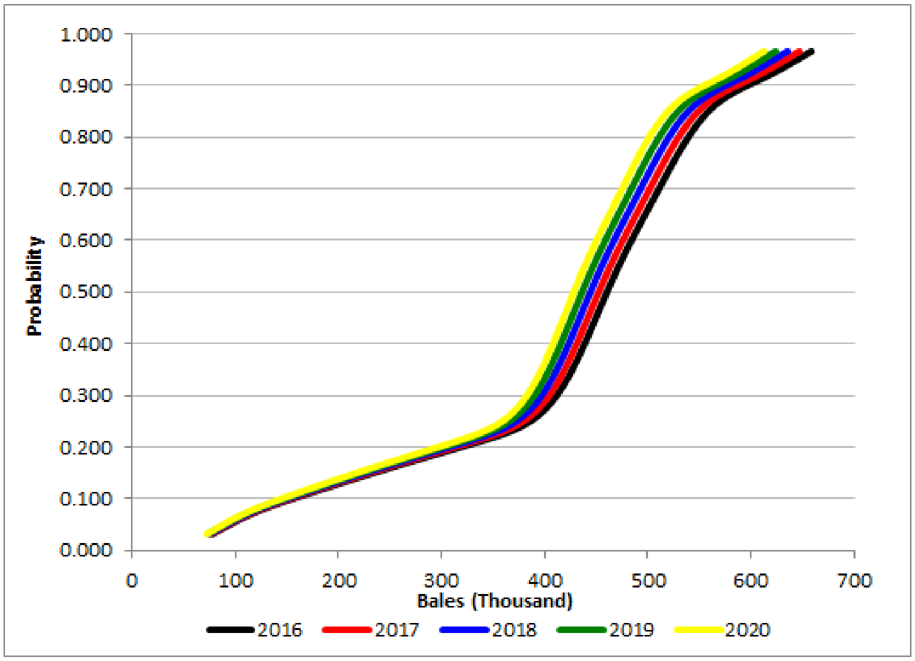


Figure 7 CDF of Bales Received by a South Texas Warehouse

The average time a bale stayed in storage was also simulated stochastically to generate the storage revenue received per bale. The average revenue generated per bale for storage was $11.70 with a CV of 13.85%. This figure tended to be fairly static as it was between ten and twelve dollars 75% of the time. The exception to this was when there was an abnormally high carry-in from the year before, which created extra revenue with bales staying in storage much longer. Figure 7 shows the CDF of average storage revenue produced that was used in the simulation model.

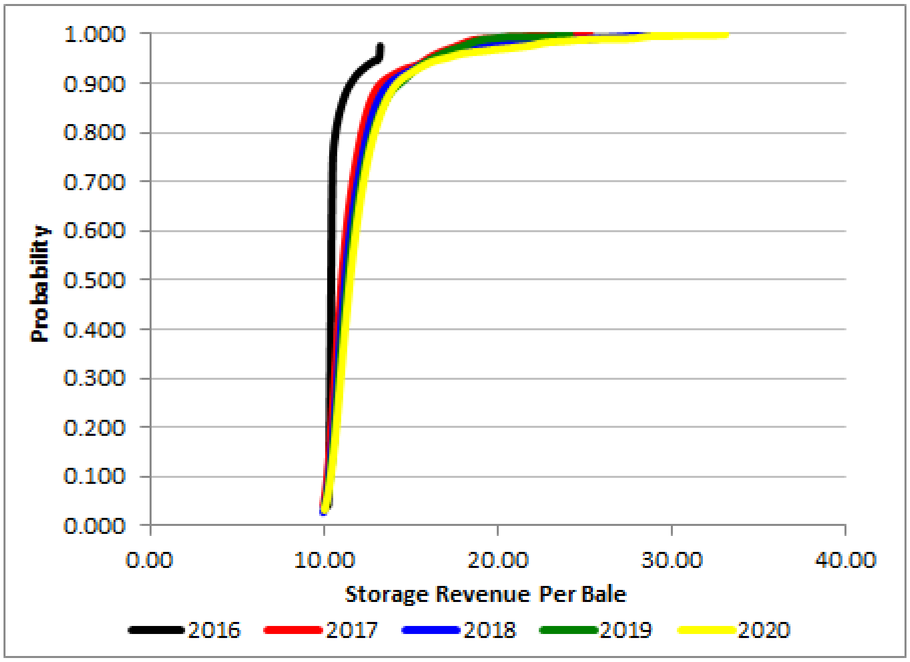


Figure 8 CDF of Storage Revenue per Bale for a South Texas Warehouse

Key Output Variables

The results of the financial simulation model were broken down into four scenarios: 1.Baseline, 2. Large Inventory MILLNet, 3. Small Inventory MILLNet, and 4. 4-Bale CLOB. Comparisons were made between each scenario and the baseline warehouse, with net income and net present value (NPV) used as the primary gauges of economic success. Net income measured the ability of the business to remain profitable through all circumstances. NPV estimated whether the business improved or not after another five years of operations. In the end, both are evaluated to determine the best warehouse method to be used to garner the best long-term results.

Table 5 Comparison of Methods for Bale Stacking in a South Texas Warehouse

South Texas Warehouse Year 1 Comparison				
	Baseline	MillNet		Four Bale CLOB
		Small Inv.	Large Inv.	
Revenue	$11,708,227	$11,708,227	$11,708,227	$11,708,227
Costs	$10,470,451	$10,396,644	$10,371,577	$10,463,488
Net Income	$1,237,776	$1,311,583	$1,336,650	$1,244,739

Stoplight charts are used to make the comparison on both the net income and NPV. The charts that relate net income show the probability of negative net income (red), between $0 and $2,000,000 (yellow), and greater than $2,000,000 (green) for each of the five simulated years. These targets were selected after evaluating actual warehouse financials and seeing that over $2,000,000 constituted the upper half of the net income distribution indicating a successful year. The NPV charts compare each of the scenarios with colors corresponding to a decline in NPV (red), between $0 and $1,500,000 (yellow), and above $1,500,000 (green).

Baseline

Figure 8 shows the probability that the baseline South Texas warehouse would have net income below $0 or greater than $2,000,000. These results indicate that negative net income typically only occurs one in 10 years. Low bale volume tended to be the main factor in producing negative results, which for the most part is out of the warehouse's control and due to a weather phenomenon. Considerations might be made as to ways to generate additional revenue during these down years. This might include storing other items beyond cotton. In general, the warehouse is profitable but can expect off years when rainfall is low and therefore causes production to be down.

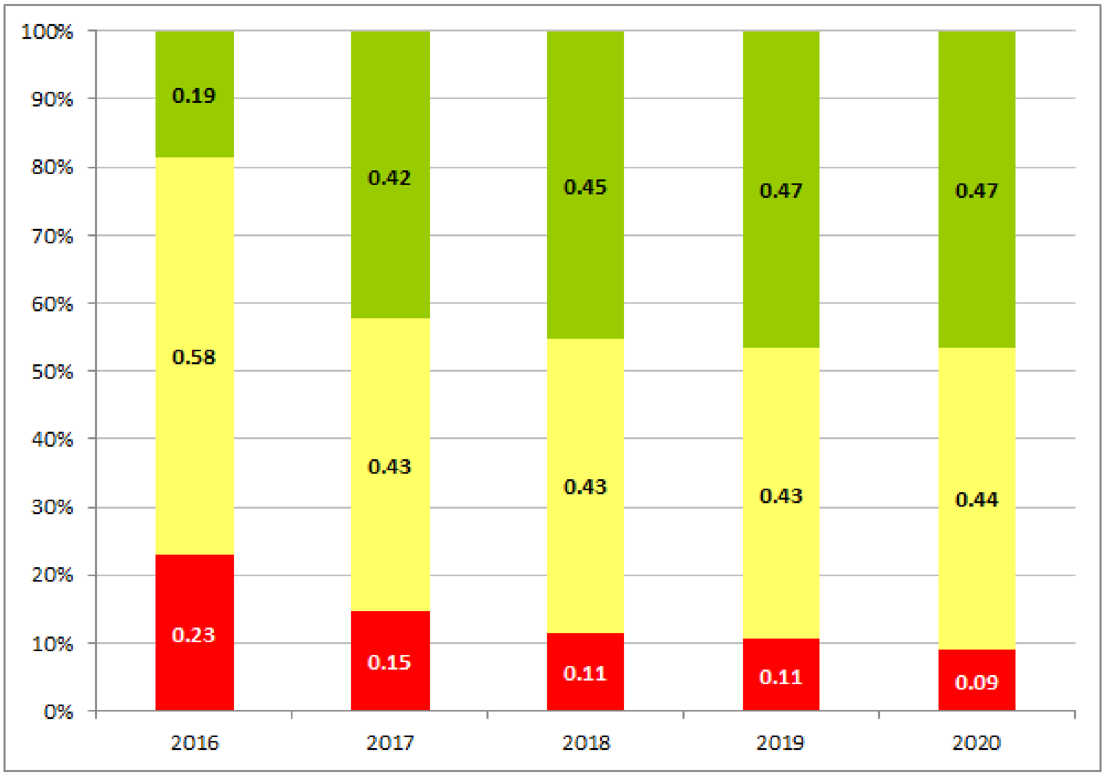


Figure 9 Stoplight Chart of a Baseline South Texas Warehouse for Probabilities for Net Income Greater than $2,000,000 and Less than $0

Large Inventory

Figure 9 shows the stoplight analysis for a South Texas warehouse utilizing the MILLNet for Merchants software under the assumption that the merchant owns approximately 20% of the available inventory. The percent of ownership was determined by Hazelrigs (2016). 20% was deemed a large share of inventory and could reduce load times by reducing the distance traveled to assemble an 88 bale load since there would be more merchant owned cotton to select from to meet the quality specifications.

This software showed a very modest improvement over the baseline scenario with about a one percent less chance of returning a negative net income. For this software to make financial sense to a warehouse, the implementation costs would need to be extremely low as the return is negligible in the long run.

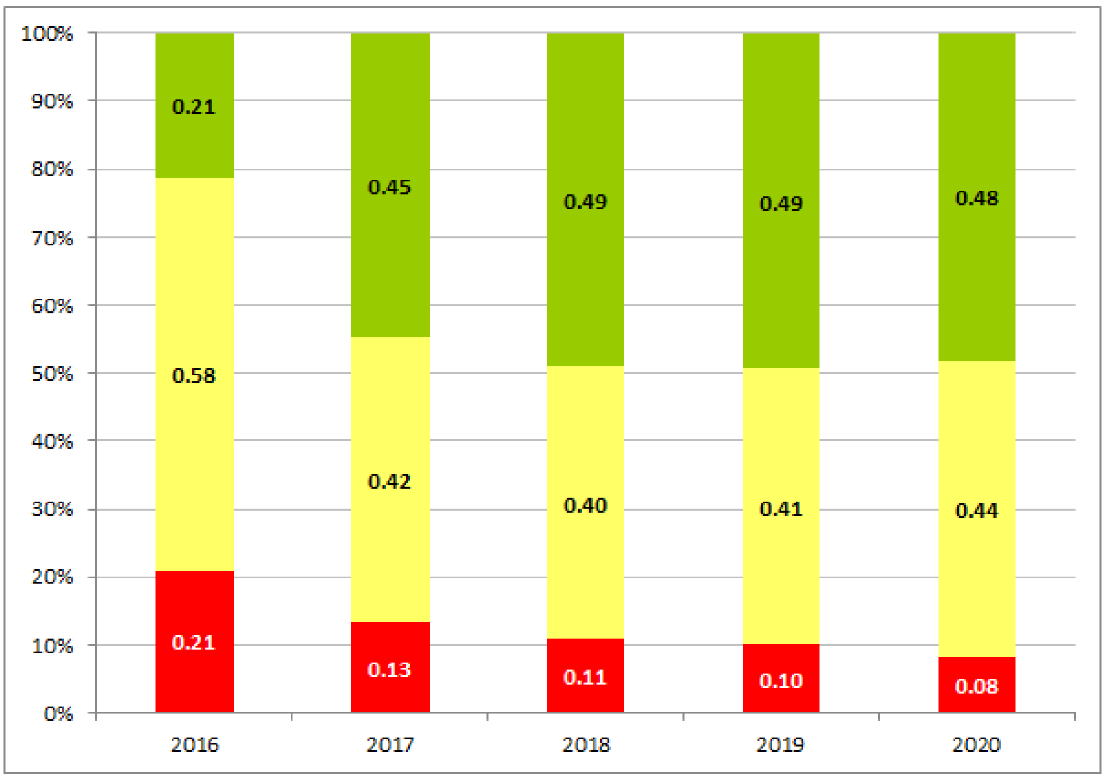


Figure 10 Stoplight Chart of a Large Inventory MILLNet South Texas Warehouse for Probabilities for Net Income Greater than $2,000,000 and Less than $0

Small Inventory

Figure 10 shows the net income probabilities for a South Texas warehouse that used MILLNet for Merchants software with the assumption that the merchant owned approximately 2% of the available inventory. Results returned similar to the baseline, providing little incentive to try and implement the software especially when the inventory is owned by many merchants.

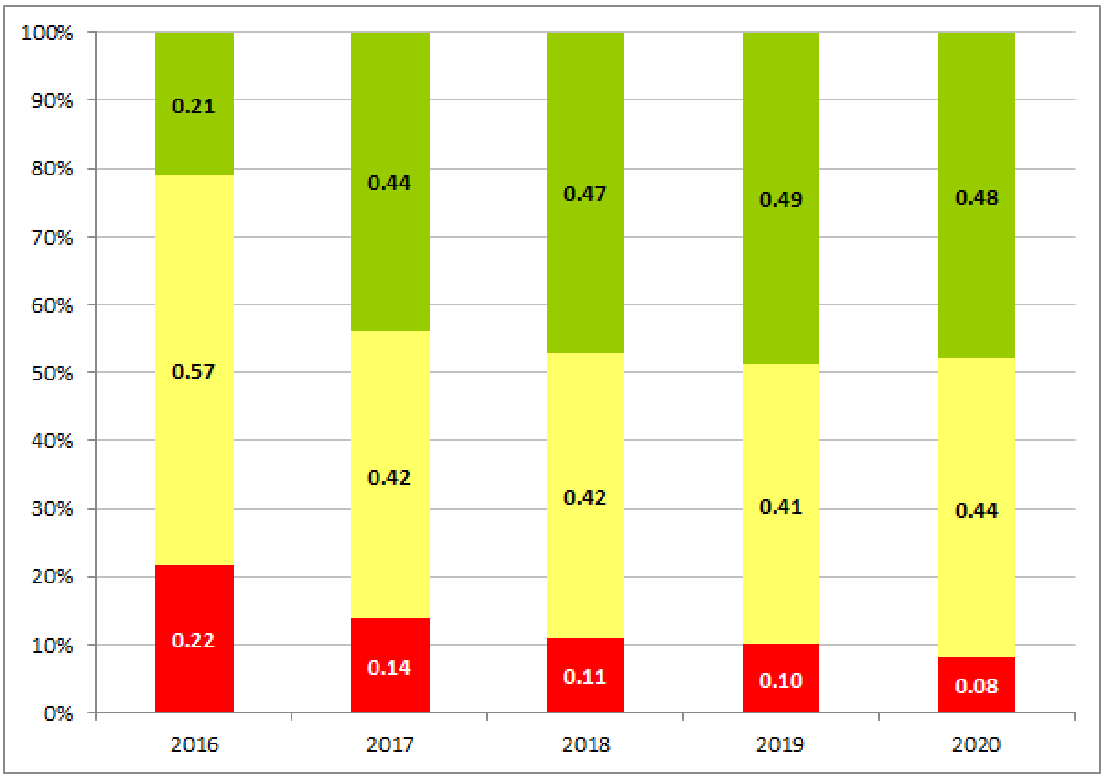


Figure 11 Stoplight Chart of a Small Inventory MILLNet South Texas Warehouse for Probabilities for Net Income Greater than $2,000,000 and Less than $0

4-Bale CLOB

Figure 11 presents the net income probabilities for the 4-bale CLOB method. 4-bale CLOB did not provide any meaningful time savings particularly in an aisle stacking warehouse. This was due to forklifts only being able to pull out one bale at a time instead of all four. There were small savings in not having to search for bales, but no savings in the actual pulling of the bale (Hazelrigs 2016). These results showed little change compared to the baseline. When considered that this method needs cooperation from the gins in the area, it is difficult to make an argument that the effort is worth the final payoff.

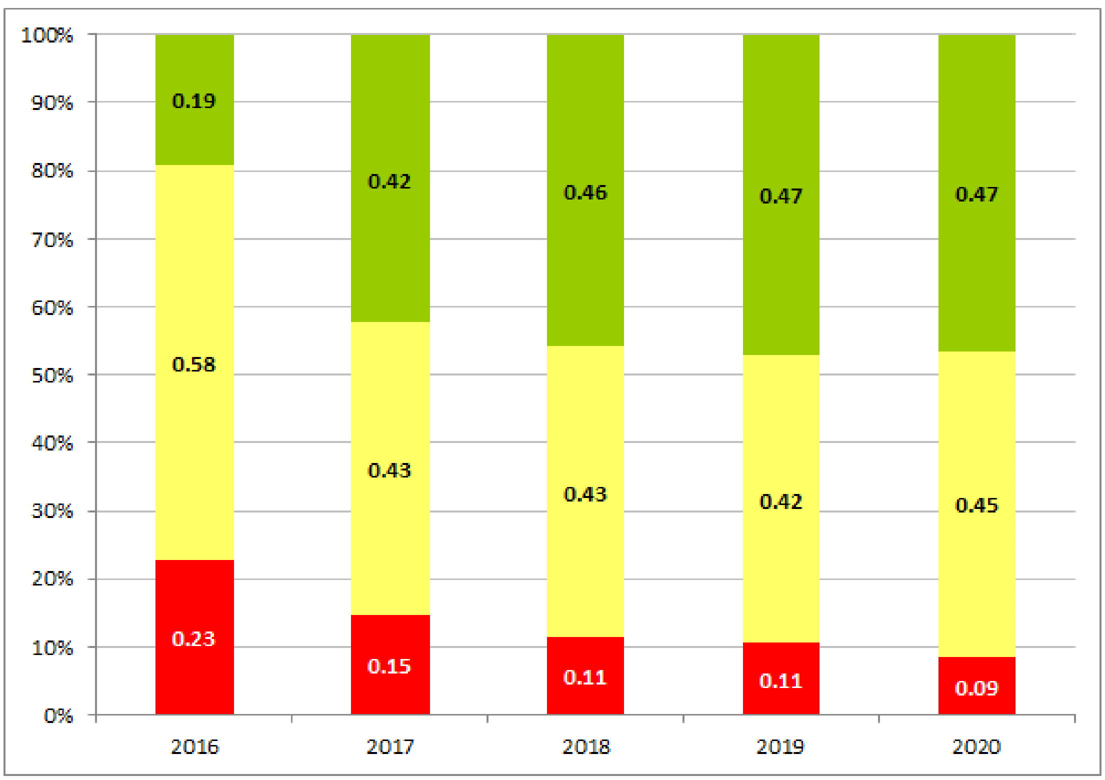


Figure 12 Stoplight Chart of a 4-Bale CLOB South Texas Warehouse for Probabilities for Net Income Greater than $2,000,000 and Less than $0

Net Present Value

Finally, Figure 12 gives a breakdown comparing the NPV of each scenario over the five year forecasting period. As expected, the best two options appear to be through using the MILLNet software. With MILLNet, the probability of a decline in the NPV is 23% compared to the other options at 27%. Clearly if warehouses have the ability to implement MILLNet, it should be considered. However, merchants must be incentivized to use the software. This might be done through quicker load out times or lower fees. Currently there is little reason for a merchant to use the software.

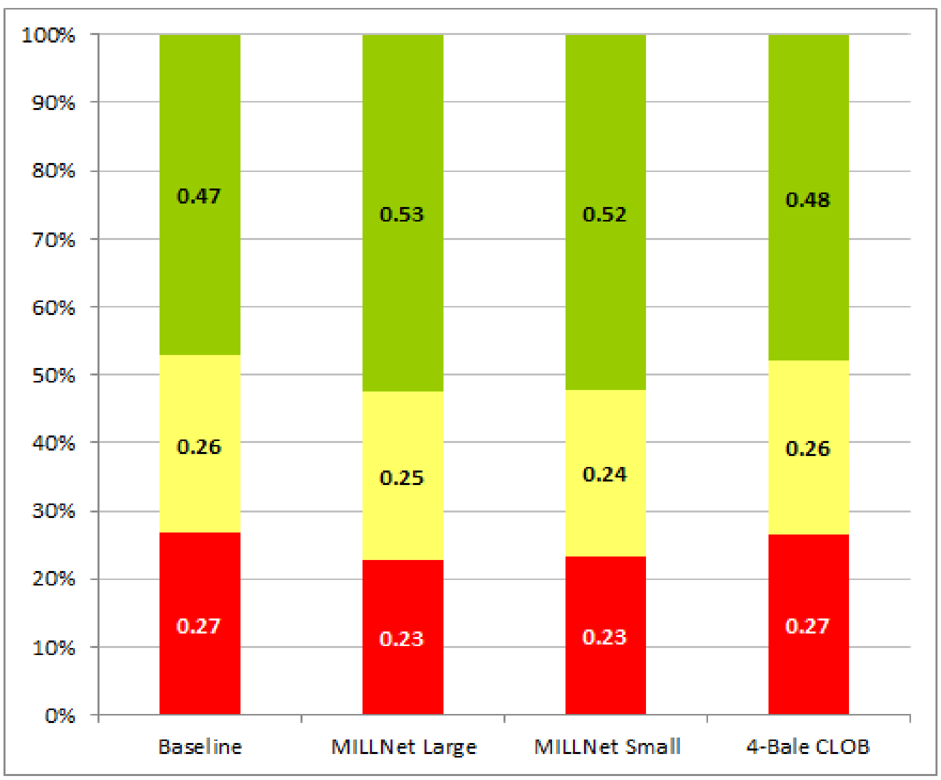


Figure 13 Stoplight Chart of a South Texas Warehouse for Probabilities for NPV Greater than $1,500,000 and Less than $0

SERF

Figure 13 shows the SERF analysis, which concluded that the MILLNet methods were the least risky scenarios. This provided evidence of the potential benefits of South Texas warehouses adopting MILLNet. The baseline scenario still provided a profitable business, but using MILLNet showed that it could increase profits and help the business minimize losses during years of low volume.

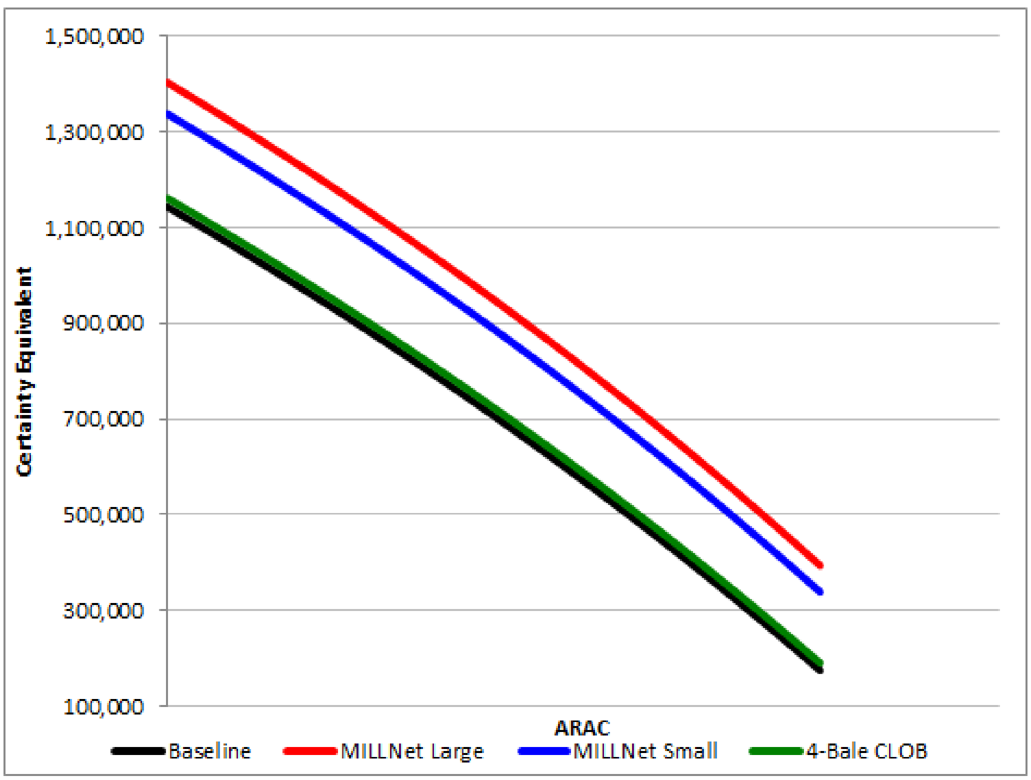


Figure 14 SERF Analysis for NPV for a South Texas Warehouse

West Texas Warehouse

A similar analysis was done based on a West Texas warehouse to show that the methodology could be applied to other regions. Bale data used was collected from NASS District 1-South. This region produces the largest volume of cotton in the State and is a major dryland region. It was therefore an ideal region to evaluate.

The number of bales received was simulated for the five forecasted years (2016-2020). The average number of bales received by the simulated medium-sized West Texas warehouse was 390,000. The coefficient of variation for the simulated bales was 37.95%. Figure 14 depicts the CDF of bales received across all five simulated years. The amount of bales received can be wide ranging given the volatility seen in yields. Figure 14 shows that there is near equal probability from 200,000 all the way to 700,000 bales.

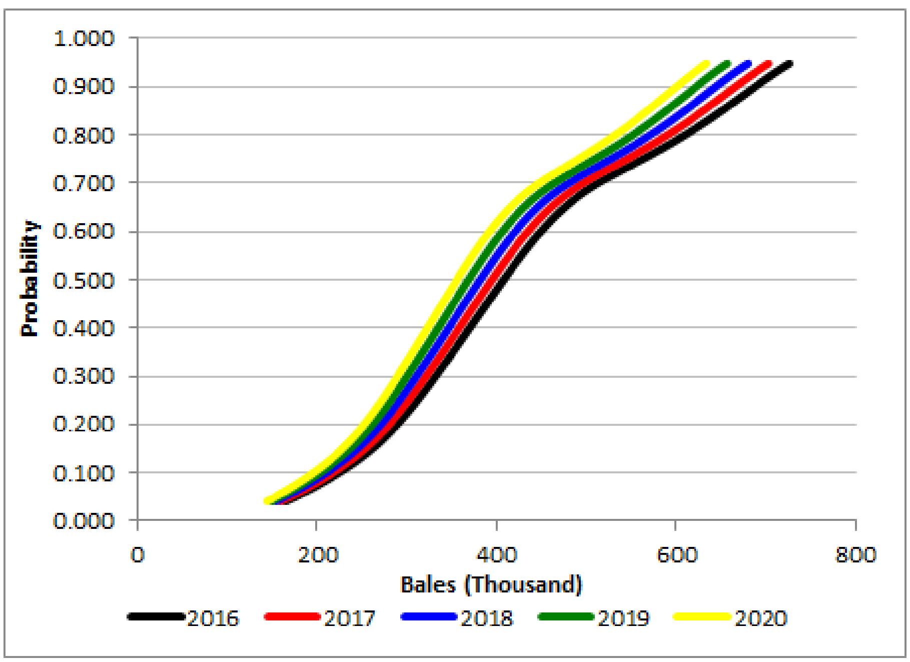


Figure 15 CDF of Bales Received by a West Texas Warehouse

The average storage revenue per bale was generated stochastically by calculating the average storage time and percent of inventory that is shipped in a given year. This can be seen in Figure 15. The average revenue produced per bale for storage was $11.07 with a CV of 13.85%. This figure tends to stay between $10 and $12 approximately 70% of the time. The lack of variation is shown in Figure 15 by the steeply sloped CDF chart, which indicates that most values fall in a small range. The main exception with storage revenue is when the carry-in tends to be above average, which generates added storage revenue from the prolonged storage time.

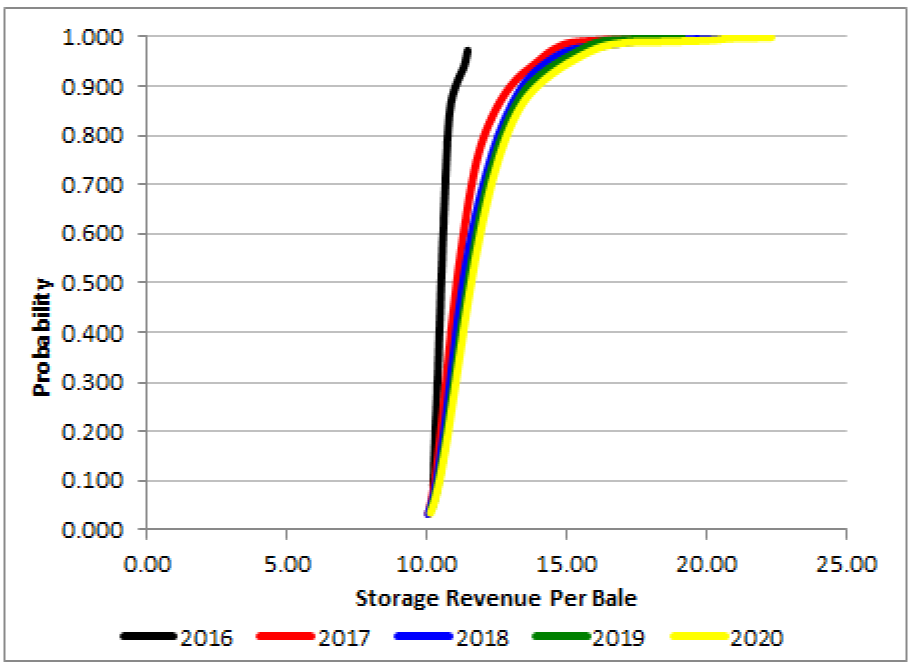


Figure 16 CDF of Storage Revenue per Bale for a West Texas Warehouse

Key Output Variables

The results of the financial simulation model were broken down into four scenarios: 1.Baseline, 2. Large Inventory MILLNet, 3. Small Inventory MILLNet, and 4. 4-Bale CLOB. Comparisons were made between each scenario and the baseline warehouse, with net income and net present value (NPV) used as the primary gauges of economic success. Net income measured the ability of the business to remain profitable through all circumstances. NPV estimated whether the business improved or not after another five years of operations. In the end, both are evaluated to determine the best warehouse method to be used to garner the best long-term results.

Table 6 Comparison of Methods for Bale Stacking in a West Texas Warehouse

West Texas Warehouse Year 1 Comparison				
	Baseline	MillNet		Four Bale CLOB
		Small Inv.	Large Inv.	
Revenue	$10,821,010	$10,821,010	$10,821,010	$10,821,010
Costs	$9,836,629	$9,768,792	$9,745,753	$9,830,229
Net Income	$984,381	$1,052,219	$1,075,258	$990,781

Baseline

Figure 16 shows the probability that the baseline West Texas warehouse would have net income below $0 or greater than $2,000,000. Similar to the South Texas results, negative net income only occurs about once in every 10 years. Low bale volume is the culprit for negative net income. With bale volume more variable in West Texas, this also reduces the times when net income exceeds $2,000,000.

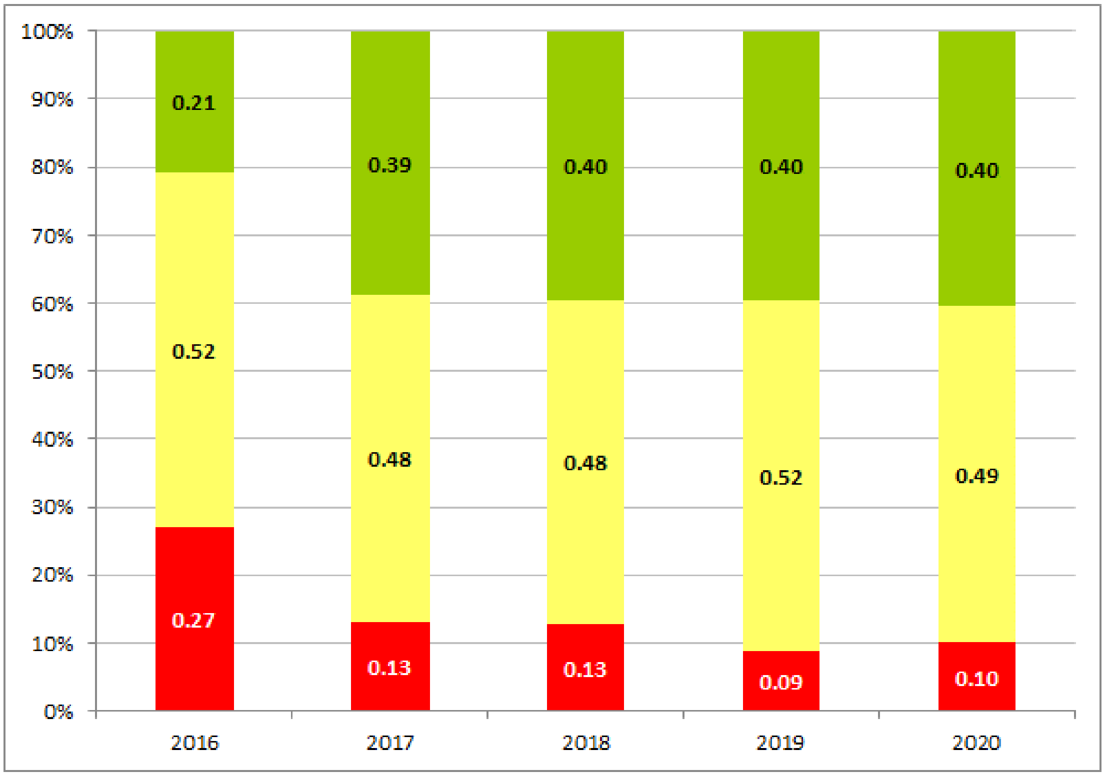


Figure 17 Stoplight Chart of a Baseline West Texas Warehouse for Probabilities for Net Income Greater than $2,000,000 and Less than $0

Large Inventory

A warehouse using MILLNet for Merchants software with a merchant owning around 20% of the available inventory is shown in Figure 17 below. This software provided a small improvement to a West Texas warehouse. This method did little for helping the warehouse avoid a year where net income is negative. It did add around a 3 percent better chance of having net income greater than $2,000,000. This indicated that there needs to be high bale volume for the software to provide value.

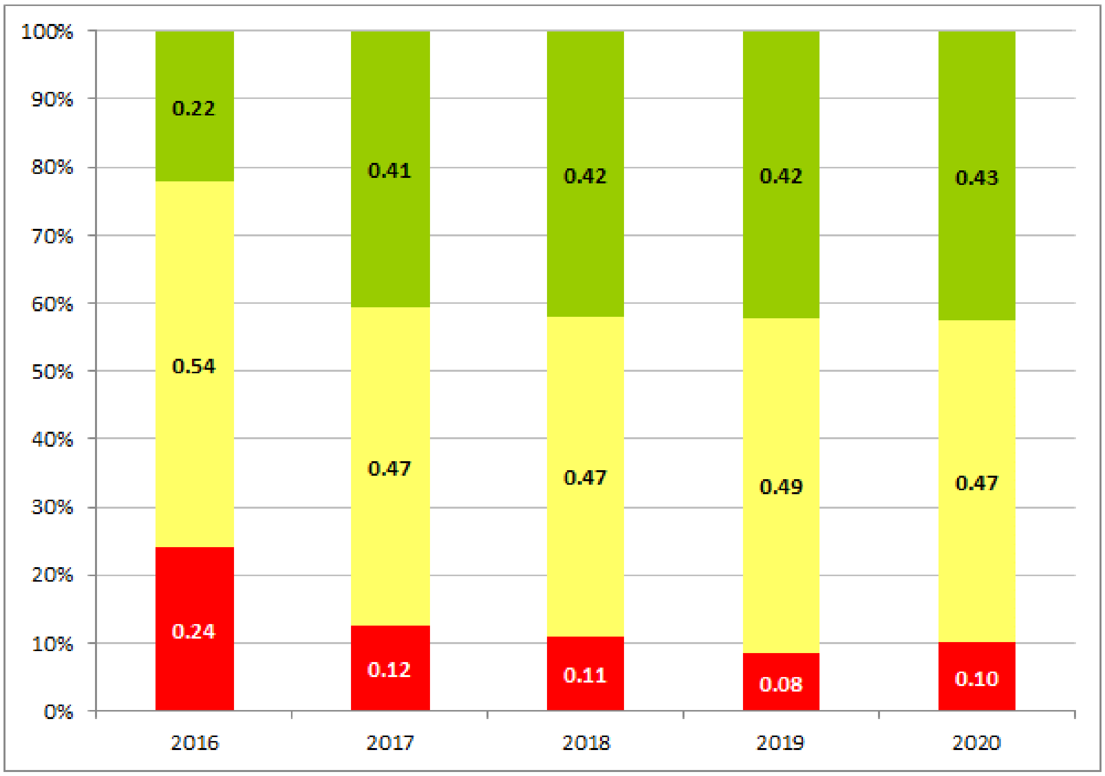


Figure 18 Stoplight Chart of a Large Inventory MILLNet West Texas Warehouse for Probabilities for Net Income Greater than $2,000,000 and Less than $0

Small Inventory

Results for a warehouse using MILLNet software but with a merchant only owning 2% were similar to when a merchant owns a larger amount. These results are shown in Figure 18 for a West Texas warehouse. This system added a two percent better chance for the business to make over $2,000,000 in net income but did not greatly alter the negative net income scenario. So, once again bale volume must be high to impact revenue.

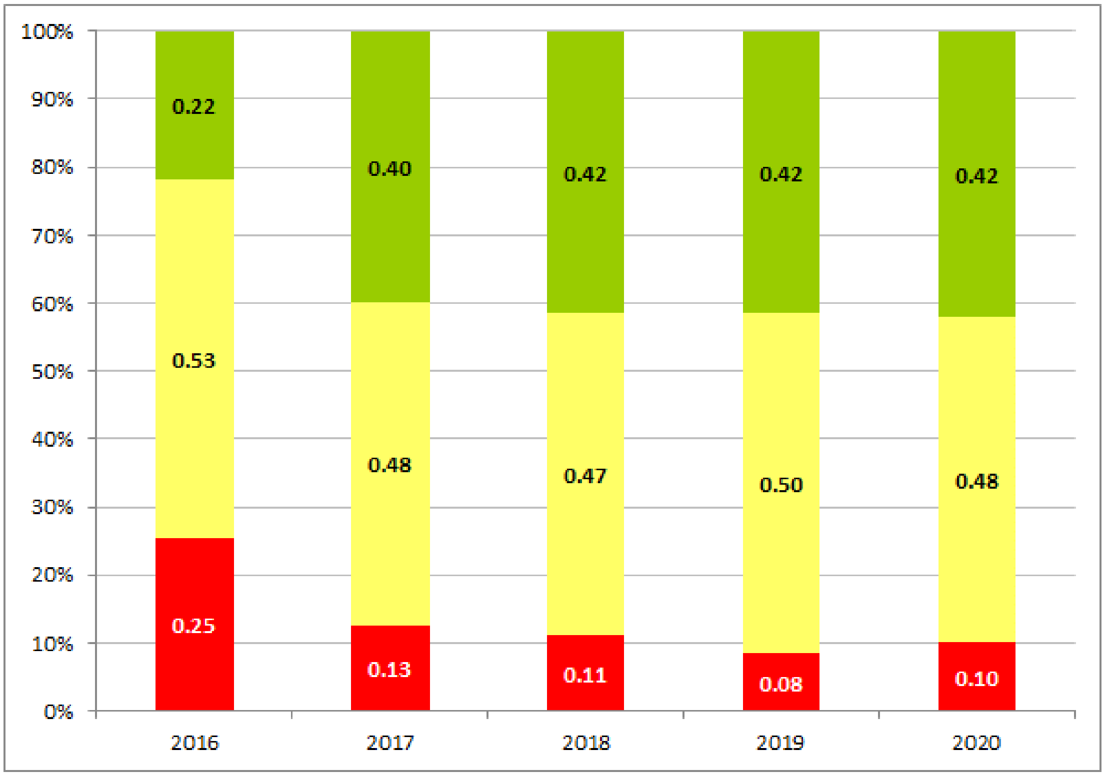


Figure 19 Stoplight Chart of a Small Inventory MILLNet West Texas Warehouse for Probabilities for Net Income Greater than $2,000,000 and Less than $0

4-Bale CLOB

Figure 19 displays the results from using the 4-bale CLOB method in a West Texas warehouse. The results turned out strikingly similar to the baseline model. This further proved that there is little economic incentive to use the 4-bale CLOB method in a warehouse that uses aisle stacking, no matter the location.

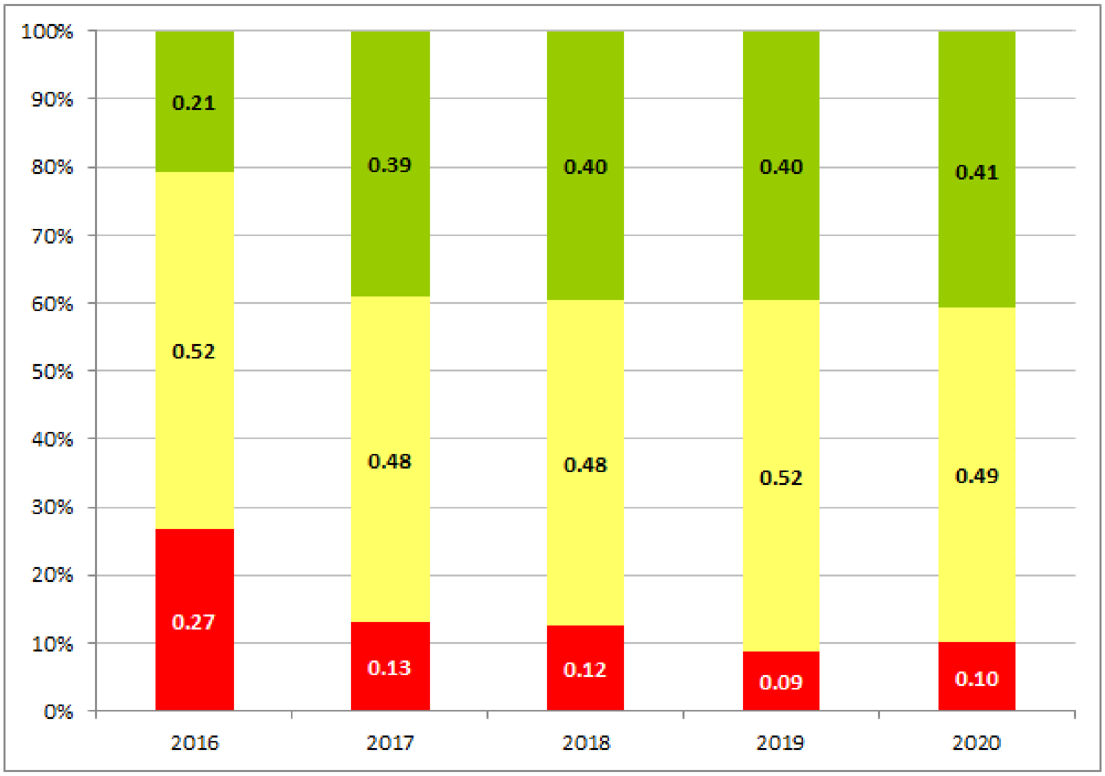


Figure 20 Stoplight Chart of a 4-Bale CLOB West Texas Warehouse for Probabilities for Net Income Greater than $2,000,000 and Less than $0

Net Present Value

The NPV was compared between each new method and the baseline. This analysis can be seen in Figure 20. Given the high variability in the number of bales a warehouse can receive in West Texas, it not surprising that the probability of a negative NPV over the five simulated years reached over 30%. The MILLNet software provided a 5% better chance of a positive NPV but still showed a 28% possibility of being negative. Warehouses that have trouble getting volume on a yearly basis must look at other avenues for generating revenue as these cost saving measures do not provide enough support.

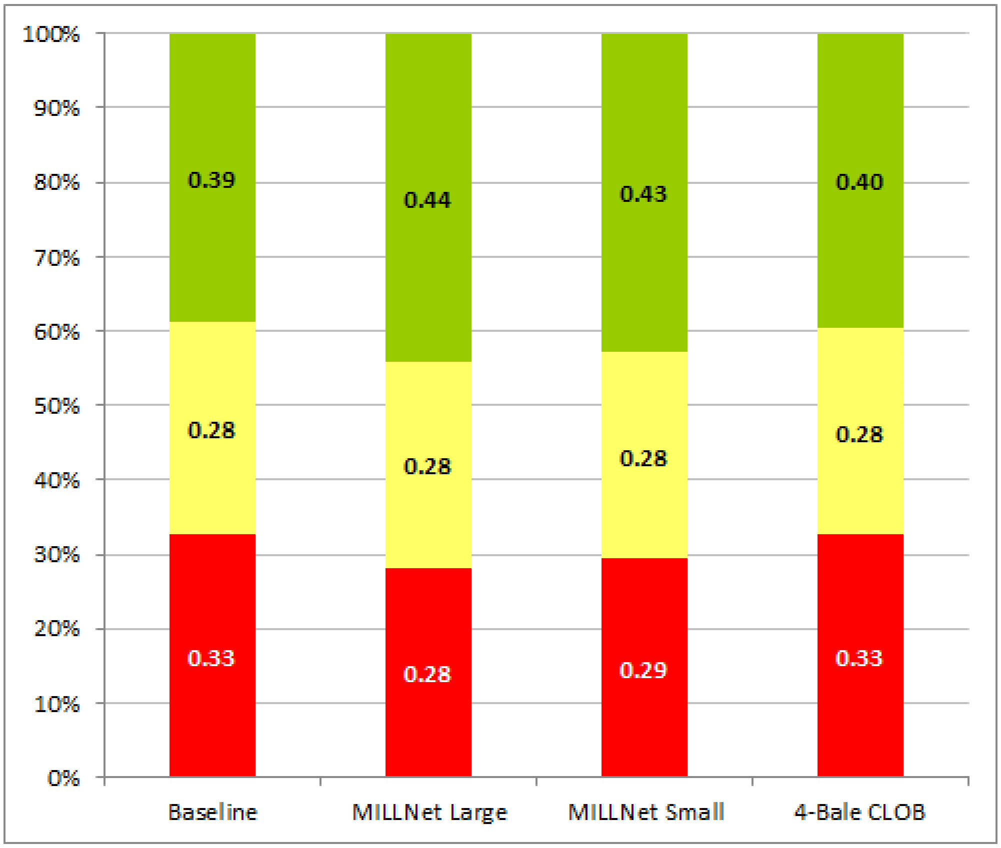


Figure 21 Stoplight Chart of a West Texas Warehouse for Probabilities for NPV Greater than $1,500,000 and Less than $0

SERF

Figure 21 displays the SERF analysis that concluded the MILLNet methods were the risk efficient options. Clearly MILLNet is worth considering if a warehouse has the option to utilize the software. The limitation with the software is that there must be bale volume to recognize the savings. Given the variability in volume that a West Texas warehouse receives, it might be difficult to justify adding this software as it might be rarely used in years with low volume.

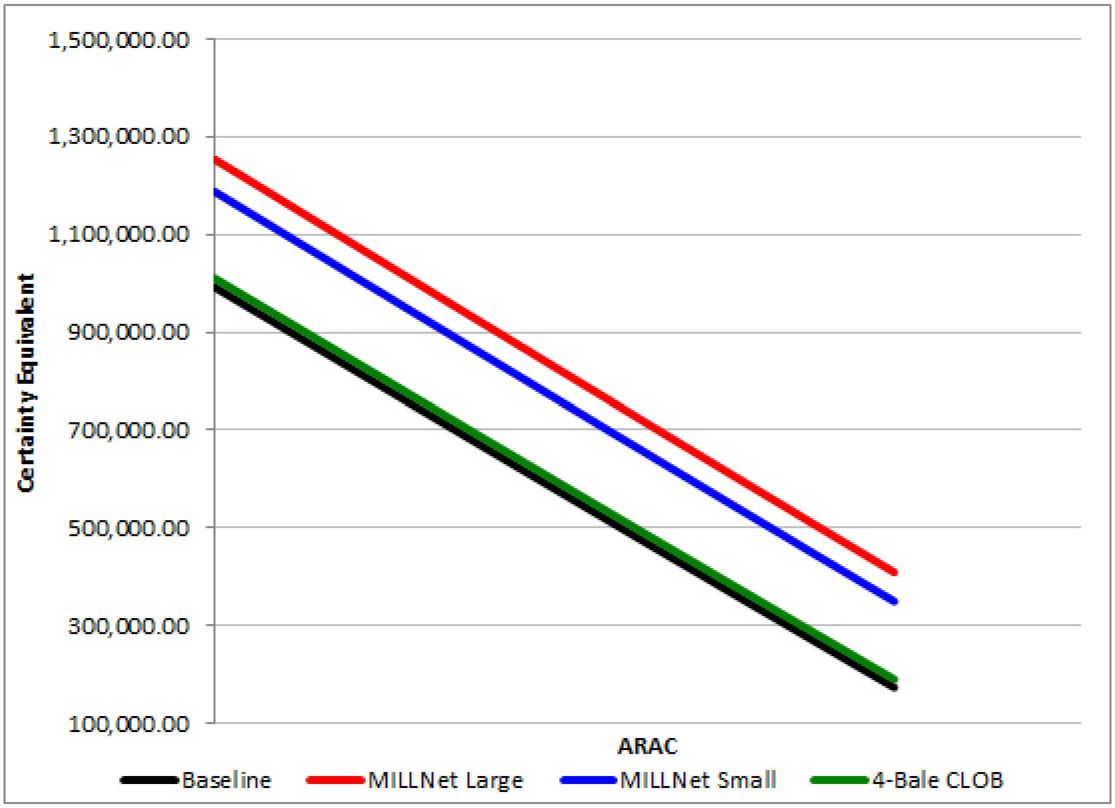


Figure 22 SERF Analysis for NPV for a West Texas Warehouse

CHAPTER V

CONCLUSIONS

This study contributes to the current limited research on the topics of cotton warehousing and general warehouse economics. It is the first known application of risk modeling of a cotton warehouse. The findings presented in this research should help warehouse management as they look to improve operations. The final chapters of this thesis are focused on concluding results and future research on the topic.

The cotton industry in the United States shifted to a primarily export market, which changed operations for cotton warehouses. Warehouses had to start shipping large volumes of cotton without advance notice as buying patterns from foreign mills were unpredictable. This strained the warehouses both logistically and financially. This thesis explored several methods designed to improve the flow of cotton through a warehouse, while improving the financial landscape as well.

Three methods were evaluated in different regions across Texas to determine the impact on a warehouse's finances. The focus was on major dryland production regions that are more exposed to production risk. The first method was the 4-bale CLOB. The other two involved using MILLNet for Merchants software with varying levels of inventory owned by a single merchant. These three methods were compared to a baseline operation to determine savings if implemented. Each method was also evaluated on a South Texas warehouse and West Texas warehouse as these represented the two major dryland growing regions. Dryland regions were chosen because the number of bales received by a warehouse plays a large role in the financial performance. Dryland areas have the largest variation in production, so they were used to account for that variability. A financial simulation model was used to simulate the warehouse for five years. The results of the simulation were compared across the five years through net income and net present value. SERF was also used to rank the riskiness of each scenario based on the simulated net incomes.

The final results indicated only small gains were achieved when using any of the three alternative bale moving options across both regions. The best results were from using the MILLNet for Merchants software in a warehouse where the merchant owns approximately 20% of the total inventory. Both MILLNet methods achieved greater results than the 4-bale CLOB. MILLNet showed potential, with the one drawback being it must be adopted by merchants. Currently there is little incentive for merchants to use the software, and this has caused limited applications. If warehouses believe the software could aid their operations, it could be beneficial to provide an incentive, whether monetarily or time based. Overall, this thesis showed a savings from each method evaluated and should help warehouses make a more informed decision about possible investments in either MILLNet or the 4-bale CLOB going forward.

CHAPTER VI

LIMITATIONS AND FUTURE WORK

Simulation modeling can be very useful when making a decision, but there are known issues that need to be considered. Models are only as good as the data used to generate the output. The validity and accuracy of the data should always be considered when evaluating results. Finally, the probability distributions produced by a model are never exact. Results might be close to the actual but will rarely be perfect. Models are designed to assist in making decisions but should never be the only input (Richardson 2008).

Warehouses each have unique cost configurations meaning results will vary between businesses. The data used in this thesis was taken from multiple warehouses, meaning there will be differences when looking at any one warehouse. The methodology of this thesis should be applied on an individual basis to determine how changes would impact the business. Evaluating one warehouse would allow the model to be tailored to fit that single business structure. The model changes could include stochastic cost variables for possibly labor or oil prices.

Possible structural changes to the production regions could be incorporated to better project the bale volume a warehouse can expect to receive. Mitchell and Robinson (2016) found good results for predicting yield and acreage for different United States growing regions. The impacts of climate change could also be evaluated. McCarl (2011) has done extensive work on the topic and found that the Texas climate has the possibility to become warmer with less rainfall. This would have further acreage and yield implication that warehouses would need to account for.

The average time a bale spends in a warehouse varies across warehouses. This is a function of demand plus warehouse location relative to nearby shipping points. There have already been structural changes to the overall demand picture for cotton with the industry already shifted to a more export oriented market. An analysis could be done to better understand what drives the timing concerning when cotton will need to be shipped. This would allow warehouses to be better prepared and could reduce transit times.

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